INTERCONNECT DEVICE WITH OPPOSINGLY ORIENTED CONTACTS

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BACKGROUND OF INVENTION

[0001] The present invention pertains to interconnect devices for electrically interconnecting the contacts of a first component to contacts of a second component.

[0002] An electrical interconnector having a plurality of electrical conductors can be used to interconnect one electronic component, such as a microprocessor or ASIC, to another electronic component, such as a printed circuit board. Typically, interconnect devices include a frame having two opposed contact surfaces for respective engagement with a corresponding contact surface of one of the electronic components. Electrical conductors (or contacts) on each side of the frame are electrically connected to the contacts of the respective components such that the two components are thereby electrically connected. The frame of the interconnect device functions to secure the positions of the electrical conductors relative to one another and to electrically isolate the electrical conductors from one another.

[0003] Today's microprocessors and ASICs often have thousands of densely spaced contacts. Correspondingly, interconnect devices for such components must have thousands of densely spaced contacts. One such known interconnect device is shown in Figures 1-2. The interconnect device 10 includes a frame 12 having a number of electrical conductors 14. Each conductor 14 has a beam contact portion 16, 18 on opposite sides of the frame 12 such that there is an electrical connection between the two contact portions 16, 18. The interconnect device 10 electrically connects the first component 20 to the second component 22. As such, the first

component 20 includes a plurality of spaced apart contacts 24 for connection to the contact portions 16 and the second component 22 includes a plurality of spaced apart contacts 26 for connection to the contact portions 18. Accordingly, each electrical conductor 16 establishes an individual electrical connection between a contact 24 of the first component 20 and a contact 26 of the second component 22.

[0004] For a interconnect device 10 such as illustrated in Figures 1-2, when the beam contacts 16, 18 are compressed due to placement of the first and second components 20, 22 on the device 10, the beam contacts move in an arc and thereby generate a wiping action against a mating surface 28 of the frame 12, resulting in a sideways force (the "wipe force") 29, as shown in Figure 3. Although the individual wipe force from one beam contact may be relatively small, for electrical devices having thousands of densely spaced contacts the cumulative wipe force of all the beam contacts of the interconnect device can be quite high. For example, testing of such devices has shown that for a interconnect device having 2400 contacts, the cumulative sideways wipe force can be twenty pounds. This can be problematic. As the conductors are compressed, the contacts must be kept in proper alignment to the mating surfaces of the components to be connected together. Such a large wipe force limits how the parts can be kept in alignment because many alignment techniques cannot withstand such large sideways wipe forces.

[0005] One known technique of mitigating this problem is to use a contact that does not generate a wipe action. Such contacts, however, lose the cleaning action that the wipe action provides. Other drawbacks of such contacts include deflection range and cost. Another known technique is to use alignment techniques that can withstand such large wipe forces, such as using large, sturdy alignment surfaces and/or alignment pins. While such techniques may be

acceptable for some applications, such large sidewalls and/or alignment pins can present space and tolerance problems in other applications.

[0006] Accordingly there exists a need for an interconnect device that minimizes or eliminates the cumulative wipe forces, yet provides the beneficial wipe action, is relatively inexpensive to manufacture, and which has the capability of satisfying tight and/or small dimensional requirements.

SUMMARY OF THE INVENTION

[0007] In one general respect, embodiments of the present invention are directed to an interconnect device for electrically interconnecting a first component to a second component. According to various embodiments, the interconnect device includes a frame having a upper side and a lower side, a first plurality of beam contacts on the upper side for connection to contacts of the first component, and a second plurality of contacts on the lower side of the frame for connection to contacts of the second component. Each beam contact on the upper side of the frame is electrically connected to a contact on the lower side of the frame. In addition, the beam contacts on the upper side of the frame are arranged such that the sum of the sideways wipe forces caused by compression of the beam contacts on the upper side of the frame due to connection of the first component to the interconnect device approximately equals zero or is below some threshold amount, such as 5 pounds. For example, a first portion of the first plurality of beam contacts may be oriented to face a first direction and a second portion of the second plurality of beam contacts may be oriented to face a second direction opposite to the first.

[0008] According to various other embodiments, the second plurality of contacts, on the lower side of the frame, may include beam contacts. The beam contacts on the lower side of the

frame may also be arranged so that the sum of the sideways wipe forces caused by compression of the beam contacts on the lower side due to connection of the second component to the interconnect device approximately equals zero or is below the threshold amount. In addition, the first component may be, for example, an integrated circuit and the second component may be a printed circuit board (PCB).

[0009] According to another embodiment, the first plurality of beam contacts, on the upper side of the frame, may be arranged in columns such that the beam contacts in a first portion of the columns are oriented in a first direction and the beam contacts in a second portion of the columns are oriented in an opposite direction relative to the first direction, such that the sum of the sideways wipe forces caused by compression of the beam contacts in the first and second portions of the columns due to connection of the first component to the interconnect device approximately equals zero or is below the threshold amount. The plurality of beam contacts on the lower side of the frame may be similarly arranged.

[0010] In another general respect, embodiments of the present invention are directed to a method of fabricating an interconnect device for electrically interconnecting a first component to a second component. The method includes molding a frame of the interconnect device such that a plurality of electrical conductors are molded into the frame, wherein each electrical conductor includes a first beam contact portion extending from an upper side of the frame and a second beam contact portion extending from a lower side of the frame. The method further includes shaping the electrical conductors such that the first beam contact portions extending from the upper side of the frame are arranged such that the sum of the sideways wipe forces caused by compression of the first beam contact portions due to connection of the first component to the interconnect device approximately equals zero or is below the threshold amount. In addition, the

method may include shaping the electrical conductors such that the second beam contact portions extending from the lower side of the frame are arranged such that the sum of the sideways wipe forces caused by compression of the second beam contact portions due to connection of the second component to the interconnect device approximately equals zero or is below the threshold amount.

DESCRIPTION OF THE FIGURES

[0011] Embodiments of the present invention are described by way of example in conjunction with the following figures, wherein:

Figures 1-2 depict a prior art interconnect device;

Figure 3 is a diagram illustrating sideways wipe forces in a prior art interconnect device;

Figures 4-7 depict an interconnect device according to various embodiments of the present invention;

Figure 8 is a diagram illustrating the cancellation of the sideways wipe forces with an interconnect device according to various embodiments of the present invention; and

Figures 9-10 illustrate an embodiment of the interconnect device according to various embodiments of the invention with solder balls connected to one side thereof.

DETAILED DESCRIPTION OF THE INVENTION

[0012] Figures 4-7 depict an interconnect device 40 according to various embodiments of the present invention. The interconnect device 40 may be used to electrically interconnect contacts 42 on a first component 44 to corresponding contacts 46 a second component 48. Figure 4 is a perspective view of the interconnect device 40 together with the first and second components 44,

48. Figure 5 is a perspective side view of a portion of the interconnect device 40 with a portion of the second (e.g., bottom) component 48. Figure 6 is another perspective view of a portion of the interconnect device 40 and Figure 7 is a top plan view of a portion of the interconnect device 40.

[0013] The contacts 42, 46 may be, for example, lands or pads of various shapes and sizes. For example, as illustrated in Figure 4, each contact 42, 46 may be a land that is a rectangular shaped flat surface. The plurality of contacts 42, 46 of the first and second components 44, 48, arranged in rows/columns as shown in Figure 4, may be considered to constitute a "land grid array." The first component 44 may be an integrated circuit such as, for example, a microprocessor or an ASIC. The second component 48 may be, for example, a printed circuit board (PCB). As such, the interconnect device 40 may be referred to as a "microprocessor connector," a "socket," an "interposer," or a "land grid array (LGA) socket."

[0014] According to various embodiments, as shown in Figures 4-7, the interconnect device 40 includes a number of electrical conductors 50 extending through a frame 52. Each conductor 50 may include a beam contact portion 54 on an upper side of the interconnect device 40 and a beam contact portion 56 on a lower side of the interconnect device 40. The upper beam contact portions 54 may contact respective and corresponding contacts 42 on the first component 44 and the lower beam contact portions 56 may similarly contact respective and corresponding contacts 46 on the second component 48. As such, the electrical conductors 50 may provide an electrical connection between the contacts 42 of the first component 44 and the corresponding contacts 46 of the second component 48.

[0015] The electrical conductors 50 may be fabricated from an electrically conductive material such as, for example, BeCu. The electrical conductors 50 may be stamped or formed

from metallic strips that are approximately 0.001 to 0.003 inches in thickness. Further, portions of the electrical conductors 50 may be completely or selectively gold-plated on one side to a thickness of between three and fifty micro-inches to enhance the conductivity of the conductors 50. The conductors 50 may be spaced, for example, 1mm apart.

[0016] The frame 52 may be made from an electrically non-conductive material, such as thermoplastic, to provide electrical insulation between the numerous conductors 50. The shape, size and design of the frame 52 can be varied to be compatible with particular variations of the first and second components 44, 48.

[0017] According to various embodiments, as shown in Figures 4-7, the frame 52 may define a number of channels 58 on both the upper and lower surfaces thereof. The channels 58 may be separated by raised sidewalls 60 on both the upper and lower surfaces of the frame 52. The beam contact portions 54, 56 may be positioned in the respective channels 58.

[0018] In the illustrated embodiments of Figures 4-7, the conductors 50 have compression-type beam contact portions 54, 56. As such, when the beam contact portions 54, 56 are compressed due to placement of the first and second components 44, 48 on the device 40, the beam contacts 54, 56 move in an arc, thereby generating sideways wipe forces. According to various embodiments of the present invention, in order to mitigate the problematic cumulative sideways wipe forces of the contacts in the prior art, a first portion of the conductors 50 of the interconnect device 40 may face one direction and a second portion of the conductors 50 may face an opposite direction. That is, for example, with reference to Figure 5, the beam contact portions 54, 56 in channels 58a, 58c may face one direction (down and to the right in Figure 5) and the beam contact portions 54, 56 in channels 58b, 58d may face in the opposite direction (up and to the left in Figure 5). When the number of beam contact portions 54 facing the first

direction equals the number of beam contact portions 54 oriented to face the second (opposite) direction, the cumulative wipe forces 61 generated by compression of the beam contacts 54 can be effectively canceled, as shown in the example of Figure 8.

[0019] Figure 8 shows an embodiment in which a portion of the frame 52 of the interconnect device 10 is used to align the component 44 on the interconnect device 10. According to other embodiments, rather than using an alignment feature of the frame 52 to align the component 44, a post, screw or solder ball, for example, may be used to align the component 44. Canceling sideways swipe forces can be especially advantageous for such alignment techniques because these small features are typically less able to withstand the cumulative sideways swipe forces involved in conventional designs.

[0020] According to various embodiments, the orientation of the conductors 50 may alternate by channel 58, as shown in the example of Figures 4-7. That is, the conductors 50 in every other channel 58 may be oriented in the first direction and the conductors in the intervening channels 58 may be oriented in the opposite direction. Thus, the configuration of the conductors 50 may be considered to be an array of columns and rows, with the columns being in the direction of the contact beams 54, 56 (*i.e.,* along the channels 58) and the rows being cross ways to the contact beams 54, 56. Orienting the conductors 50 in a particular column (i.e., channel 58) in the same direction may simplify manufacture and keep conductors pointed in one direction from interfering with conductors in the other direction.

[0021] According to alternative embodiments, rather than an every-other-one arrangement, the conductors in two (or more) adjacent channels may face the first direction and the conductors in the adjacent two (or more) channels may face the opposite direction (an every-other-two arrangement), and so on. When the number of conductors 50 in the first direction roughly equals

the number of conductors 50 in the opposite direction, the cumulative wipe forces generated by compression of the beam contacts can be effectively canceled. That is, the vector sum of the wipe forces may approximately equal zero. The number of conductors oriented in the first direction need not exactly equal the number in the opposite direction. According to various other configurations, the conductors may be oriented in more than two different directions (such as three or four different directions), such that the vector sum of the cumulative wipe forces approximately equals zero. According to other embodiments, the vector sum of the cumulative wipe forces may be less that some threshold, such as the amount of force that the alignment device can easily withstand, such five pounds or less.

[0022] According to various embodiments, a midsection of the electrical conductors 50 may be molded in place in the frame 52 such that the beam contact portions 54, 56 extend outwardly from the frame 52 on the upper and lower sides, respectively, thereof. The beam contact portions 54, 56 may be shaped before or after the midsections of the conductors 50 are molded into place within the frame 52. As shown in Figures 6 and 7, the opposite direction contact beams may be offset such that, when compressed, the contact tips 62 are in line or a set offset distance from each other.

[0023] According to other embodiments, the frame 52 may define a plurality of holes, and the mid-portions of the conductors 50 may be disposed in the holes. Also, according to various embodiments, the frame 52 may be flat and therefore not include channels or ribs 58, as shown in Figures 4-7.

[0024] In the illustrated embodiments of Figures 4-7, the beam contacts 54, 56 on each side of the interconnect device 40 are oriented to cancel the sideways wipe forces. According to various other embodiments, only the beam contacts on one side of the interconnect device 40

(such as the beam contacts 54 on the upper side of the frame 52) may be oriented to cancel the sideways wipe forces. Also in the illustrated embodiments of the Figures 4-7, the beam contacts 54, 56 are shown as compression-type contacts. According to various other embodiments, the contacts on one side of the interconnect device 40 (such as the contacts 54 on the lower side) may be, for example, surface mount soldered (SMT) contacts or ball grid array (BGA) type contacts. For example, the contacts 54 on the upper side of the frame 52 may be pressure-type beam contacts (oriented to cancel sideways swipe forces), and the contacts 56 on the lower side of the frame 52 may comprise, for example, a land 70 with a solder ball 72 connected thereto, as shown in Figures 9 and 10. The solder balls 72 may be connected to the lands 70 prior to connection to the second component 48, as described in my co-pending U.S. patent application Serial No. 10/678,250, entitled "Interconnect Apparatus, System, and Method," filed January 30, 2004, which is incorporated herein by reference. Alternatively, the solder balls 72 may be connected to the contacts 46 of the second component 48 prior to connection to the lands 70 of the interconnect device 40.

[0025] Also in the illustrated embodiments of Figures 4-7, the channels 58 on the upper and lower sides of the frame 52 are lined up. That is, a channel 58 on the lower side is directly below a channel 58 on the upper side. According to yet other embodiments, the channels 58 on the upper and lower sides of the frame 52 may be offset such that a channel on the lower side is not directly below a channel on the upper side. For more details regarding such embodiments, refer to U.S. Patent 5,967,797, U.S. Patent 6,045,367, U.S. Patent 6,604,950, published U.S. Patent Application 2002/0160632 and published U.S. Patent Application 2003/0114025, which are incorporated herein by reference.

[0026] While several embodiments of the invention have been described, it should be apparent, that various modifications, alterations and adaptations to those embodiments may occur to persons skilled in the art with the attainment of some or all of the advantages of the present invention. For example, different materials may be used and steps of the disclosed processes may be performed in different orders. It is therefore intended to cover all such modifications, alterations and adaptations without departing from the scope and spirit of the present invention as defined by the appended claims.